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Cleaning of the equipment used for carcass fabrication at large pig-slaughtering plants

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SUMMARY

If pork is to have the reliably long storage life required for overseas trading and centralized preparation of shelf-ready product, it must be prepared to a high hygienic standard. Pork of high hygienic quality can be obtained only if sources of bacterial contamination are eliminated from pork cutting facilities. That requires the consistent, good cleaning of pork fabricating equipment.

Good cleaning involves; the effective removal of organic soil from equipment surfaces that contact meat either directly or indirectly; drying of cleaned equipment to preclude the proliferation of the bacteria remaining on well-cleaned surfaces; and disinfection of clean, dried surfaces, to reduce the numbers of the residual microflora. Proper cleaning and drying are of far greater hygienic importance than disinfection. Moreover, disinfective treatments will be ineffective unless cleaning and drying have been properly implemented.

Techniques for cleaning meat cutting equipment are discussed, and illustrated by reference to microbial data from pork cutting facilities. The appropriate approaches to managing, and assessing the efficacy of, cleaning processes are considered.

RÉSUMÉ

Pour que la viande de porc puisse garder la durée de conservation prolongée requise à l'exportation outre-mer et à la préparation de produits prêts à la consommation, elle doit être préparée sous des conditions hautement hygiéniques. Une viande de haute qualité ne peut être obtenue que si la source de contamination bactérienne est éliminée des établissements de traitement de la viande de porc et ceci, demande une attention particulière à la propreté des instruments utilisés pour le traitement des viandes.

Une bonne hygiène comprend entre autres; l'élimination du sol organique de l'équipement en contact de près ou de loin avec la viande, le séchage, pour écarter la prolifération des bactéries qui demeurent sur les surfaces propres, suivie d'une désinfection des surfaces propres et sèches pour éliminer la microflore résiduelle. Le nettoyage et le séchage de l'équipement ont une importance plus grande que la désinfection et cette dernière sera inefficace si le nettoyage et le séchage n'ont pas été réalisés en premier.

Des techniques de nettoyage de l'équipement utilisé pour le traitement des viandes sont présentées et illustrées avec référence aux données sur la microflore prises dans des établissements de traitement de la viande de porc. De plus, la gestion et l'évaluation des procédés de nettoyage sont analysées.

INTRODUCTION

Canadian pork packers are increasingly seeking an extended storage life for their raw product. Most are at present interested in the export of chilled primal cuts to Pacific Rim countries. Others are attempting to devise systems for the delivery of display packaged consumer cuts to retail outlets, in response to the strong desire of supermarket operators for centrally-prepared, consumer-ready meats with a reliable storage-plus-display life that is sufficient for normal retailing purposes.

For both of those trades to be possible, the normal storage life of raw pork must be extended by the use of preservative packagings. However, no preservative packaging of itself can confer on raw meat a reliably long storage life. Consistently satisfactory performance can be obtained only when the product is of a high hygienic standard when packaged, and product temperatures are well-controlled during its storage and distribution (Gill & Molin, 1991).

Unfortunately, the hygienic condition of pork is generally poorer than that of other red meats (Gill & Harrison, 1989). Its hygienic condition is very much poorer than that of meats specifically processed for prolonged stability in preservative packagings (Gill, 1989). Unless the hygienic deficiencies of pork can be remedied, there is no possibility of achieving for that meat the lengthy, reliable storage life that many overseas packers now obtain for beef, lamb and venison. Recent studies have identified two principal causes of the poor microbiological condition of pork (Gill & Bryant, 1992). The primary fault lies with the dehairing equipment. Much detritus inevitably accumulates in the dehairer. The warm, moist conditions that exist within the equipment allow the detritus to develop a large and varied bacterial flora, containing both mesophilic pathogens and psychrotrophic, spoilage types. That flora is distributed over carcasses via both the rotating flails and the water that is recirculated through the equipment. Consequently, carcasses, that exit the scalding tank carrying a relatively small flora composed solely of thermotolerant, non-spoilage organisms, will leave the dehairing equipment carrying a substantial flora that includes a large fraction of spoilage bacteria. The numbers of those organisms are little affected by the singeing and polishing operations. Thus, the hygienic condition of pig carcasses is badly compromised before they are eviscerated.

Bacteria from the skin are spread to the meat tissues during the evisceration of carcasses, but the numbers transferred to meat during evisceration are relatively small. Larger numbers are transferred during the breaking down of carcasses. Some such contamination of the meat is at present inevitable. However, investigations of commercial processes have shown that substantial numbers of the spoilage bacteria on pork are originating from the cutting facility itself. Those latter organisms can include large fractions of the species that are the causative agents of early spoilage of pork in preservative packagings (Shay and Egan, 1986; Gill & Bryant, 1992). Such contaminations is avoidable, and action should be taken to prevent it.

For bacteria originating from the fabrication facility to contaminate product in high number, there must be persistent sources of contamination within the fabrication process. Persistent sources of contamination can exist only if cleaning in the fabrication facility is

inadequate. It is therefore necessary for pork packers to develop procedures that will assure the routine, effective cleaning of their fabrication facilities.

FABRICATION FACILITIES FOR PIG CARCASSES

The general form of carcass fabrication facilities is similar at all large plants for processing pigs (Fig. 1).

The carcasses enter the fabrication facility as split sides. Each side is first divided, by means of band or circular saws, into a shoulder, midpiece, and ham portion. The three types of portion are passed to separate fabrication lines.

Hams are usually subject only to manual trimming before they are packed or passed to curing.

Shoulders are divided by a saw into butt and picnic portions. A second saw is used to remove the hock from each picnic portion. The butts and picnics are skinned by separate machines. Both portions are then manually trimmed.

Each midpiece is split into a loin and a belly portion. The two types of portion pass to separate fabrication lines. The loins are mechanically skinned, then manually trimmed. The bellies are compacted by a revolving drum, to flatten the previously curved cuts. The spare ribs are removed, usually manually, then each belly is mechanically skinned before it is manually trimmed.

In addition to the fabrication lines, there are usually further belts and/or chutes for conveying skin, trimmings and off-cuts to stations for their collection.

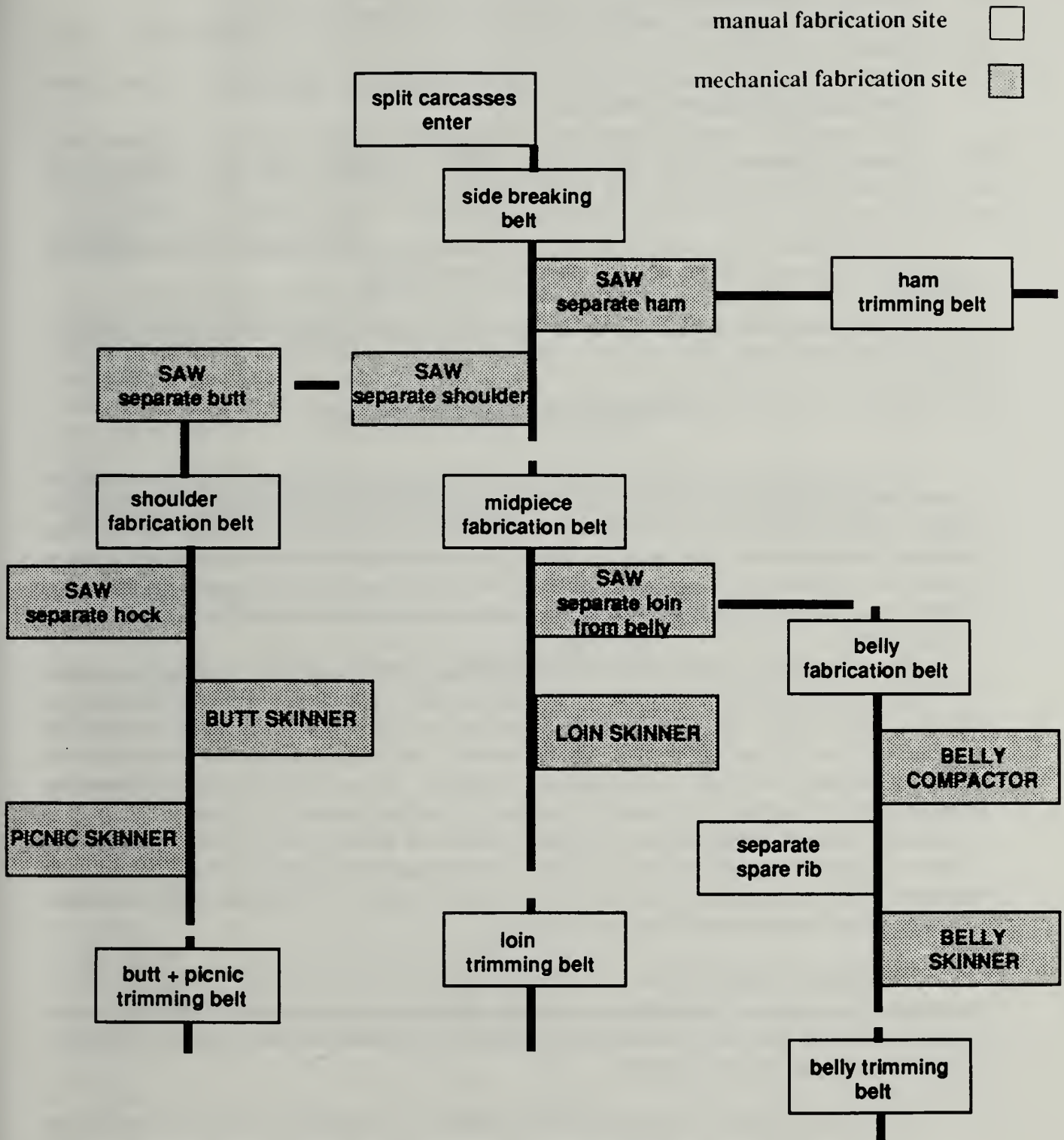
Despite a basic similarity between fabrication processes, each pig carcass fabrication facility will exhibit unique features. That uniqueness arises from factors peculiar to each plant. Examples of such factors are the need to accommodate the fabrication process within a particular floor space or spaces, the range of equipment employed, the presence of plant-modified or -specified equipment, the mix of products that finally leave the fabrication process, etc.

In consequence of the unique features of each fabrication process, there will be a corresponding uniqueness in an effective cleaning process at each plant. The detailed planning of a cleaning process therefore requires a similarly detailed familiarity with the fabrication facility, if the general principles of cleaning are to be properly applied.

THE SCOPE OF THE CLEANING PROCESS

For any cleaning procedure to be successful, the scope of its application must be appreciated by all who are involved. If those concerned with the actual cleaning are furnished with only general instructions, on the assumption that soiling and detritus will be obvious and removed, then items of importance are likely to be missed.

Fig 1. The pig carcass fabrication process



Specification of the cleaning process should commence with a plan of the processing area(s). The following should be indicated on the plan:

1. Each fixed item of equipment.
2. Each drive mechanism that is spaced apart from the item of fixed equipment that it serves.
3. The positions that should be occupied by the larger, movable items of equipment after processing is completed for the day.
4. The position(s) where the small items of equipment used by individual workers (e.g. knives, scabbards, mesh, gloves, etc) will be deposited when daily processing is concluded.

A descriptive list of all the identified items should also be prepared. For the small items used by individual workers, the number of each should be noted.

There will then be a clear view of all the items that have to be encompassed in a cleaning process.

ACCESSABILITY OF EQUIPMENT

Most pig carcass fabrication processes have been developed and modified over a number of years, with the primary objective of speeding and facilitating carcass fabrication. The systems usually appear to have been implemented without excessive regard for the fact that all meat processing equipment will require daily cleaning. Consequently, it is not uncommon for access to some items of fixed equipment to be partially or wholly obscured. Obviously, equipment that is difficult to access will tend to be overlooked, and cleaning of it may be wholly neglected.

Therefore, each item of equipment should be inspected, to determine if it can be accessed for effective cleaning. In making that inspection it must be appreciated that effective cleaning does not only involve the meat contacting surfaces of equipment. Any other area of the equipment in which detritus or soil can accumulate, and then possibly be passed to food contacting surfaces, must also be accessible for cleaning. Thus, rollers supporting conveying belts, and driving mechanisms, should be included in routine cleaning if they are not to become sources for product contamination. Particular attention should also be paid to equipment adjacent to powered saws. Saws will inevitably throw quantities of organic dust for considerable distances. That material can accumulate on obscured areas of other equipment, and there become a potent source for product contamination.

The hygienic risks that arise when equipment is not fully accessible for cleaning can be illustrated by reference to the findings at a single plant for that part of the fabrication process concerned with the fabrication of the loins. Four points of inadequate cleaning were discerned in that limited section of the process.

1. In that plant, as in most, much equipment is concentrated around the area where the pig sides are first broken. Consequently, the circular saw used for dividing

the belly from the loin throws meat dust onto other equipment. Part of that dust accumulated on the outside of a chute, at a point that is obscured, to any usual view, by other pieces of equipment.

2. A conveying belt of rubber coated canvas was found to have several rollers wound with threads from the fraying belt edges.
3. Pieces of muscle tissue were recovered from the guarded upper belt of the loin skinner.
4. Much detritus was found within the guard covering a belt drive mechanism.

Samples of those materials collected immediately before processing started yielded bacteria in numbers about 10^9 /g, with spoilage bacteria greatly predominating in the flora (Table 1). Clearly, the contamination of food contact surfaces by such materials must have deleterious effects on product storage life.

Obscured areas where detritus will consistently accumulate should be clearly identified to those responsible for cleaning. Where such an area is obscured by a guard that is fixed, or which opens insufficiently, consideration should be given to modifying the guard attachments, to allow the equipment to be exposed for convenient cleaning. Where equipment modification to allow access for cleaning is not a practicable proposition, effective cleaning will depend upon appropriate, routine attention by cleaners to areas of concern.

Table 1. The microbiological conditions of various types of detritus recovered from pork fabrication equipment one hour before fabrication commenced at a pig processing plant.

Type of detritus	Microflora							
	No/g	Composition %						
		Spoilage types						Non-spoilage types
		Pse	Ac/M	F/A	Ent	Bro	Lac	
Muscle tissue	1.3×10^9	53	4	14	2	24	3	---
Meat-saw dust	1.8×10^9	64	24	5	---	---	7	---
Canvas thread	7.7×10^9	20	2	21	3	18	2	34
Detritus from a drive mechanism	2.0×10^7	14	3	1	---	82	---	---

Pse=pseudomonads; Ac/M=acinetobacteria/moraxellae; F/A=flavobacteria/alteromonads; Ent=entrobacteria; Bro= *Brochothrix thermosphacta*; Lac=lactobacilli. Non-spoilage types = micrococci and bacilli.

CLEANING OF LARGE ITEMS OF EQUIPMENT

ORGANIZATION OF THE CLEANING PROCESS

Little will be gained by scrupulous cleaning of some piece of equipment if it is then recontaminated by soil carried in cleaning water from adjacent equipment. Therefore, cleaning of equipment items must follow a regular sequence, to assure that contaminated water flows towards uncleaned areas rather than back to previously cleaned equipment. Cleaning must thus proceed from top to bottom, and in a consistent direction along any line of equipment.

Before any cleaning commences, all movable items of large equipment should be checked at, and when necessary relocated to, their established positions. That will assure that none of those items are neglected, or cleaned in positions where other equipment may be recontaminated.

All guards on equipment should be opened or removed, so that guarded areas are not overlooked during cleaning.

PRELIMINARY CLEANING

Accumulations and large pieces of detritus should be brushed or scraped from equipment. That will reduce the amount of soil that may be dispersed over other equipment during subsequent cleaning. The brushes and scrappers that are used must be made of impermeable materials, and be thoroughly cleaned themselves after they have been used.

Areas where refractory, dried soils have accumulated should be coated with a foam or gel cleaning agent (Edelmeyer, 1982). The purpose of the treatment is to soften such soils, so that they can be removed during subsequent cleaning. Little will be gained by applying a foam or gel to surfaces on which the soil remains moist, and thus remains amenable to mechanical removal.

MECHANICAL CLEANING

The large amounts of equipment in pig carcass fabrication facilities dictates the extensive use of mechanical rather than manual cleaning. Successful cleaning, whether manual or mechanical, depends upon the application of mechanical force to dislodge adhering organic material (Jennings, 1965). However, dislodgment alone will be insufficient to wholly remove all fatty material, which will coalesce on any available surface. Removal of fat will be assured only when the initial temperature of the cleaning water is sufficiently high to melt it. If the cleaning water remains above the melting point of the fat, the water alone will adequately clean equipment. However, if the water does not remain sufficiently warm while it is flowing from the equipment, the solidifying fat will be redeposited. Then, surfactants (detergents) will have to be included in the cleaning water, so that the fat is emulsified when water is forcefully applied to the soil (Schmidt, 1983).

Mechanical cleaning of food plants can be undertaken with jets of high pressure water or 'wet' steam, (Table 2). Either technique can be used effectively in pig carcass fabrication facilities.

Table 2. Operating specifications for mechanical cleaning of equipment by high pressure water or steam jets.

Specification	High pressure water	'Wet' steam
Mode of application	Fan-shaped jet	Fan-shaped jet
Nozzle temperature	55±5°C	125±5°C
Nozzle pressure	3 to 6 MPa	2 to 3 MPa
Maximum distance of nozzle from surface	20 cm	60 cm
Volume of water applied	20 to 40 l/m ²	2 to 5 l/m ²

Cleaning with high pressure water

For effective cleaning, high pressure water should be applied as a fan-shaped jet with a nozzle pressure greater than 3 MPa (400 PSIG) and at a temperature above 50°C. Generally, cleaning is facilitated by increasing the pressure and temperature of the jet. However, the maximum pressure is in practice limited to about 6 MPa (<1000 PSIG), to avoid possible damage to equipment and the facility structure, while operating at high water temperatures involves increasing energy costs. It is then a convenient practice to operate with water temperatures about 60°C, with the addition of a detergent to the water to preclude the redeposition of fat from cooled water. Those conditions will allow good cleaning when the water is applied at between 20 and 40 liters per square meter of surface (Schmidt & Bem, 1978).

When cleaning with high pressure water it must be appreciated that both the pressure and temperature of the water decline rapidly with increasing distance from the nozzle. Consequently, water applied from too great a distance will not strike surfaces with sufficient force to detach proteinaceous soil and emulsify fat, or with sufficient temperature to melt fatty deposits. To be effective, the water must be applied with the nozzle at no greater distance from the surface than 20 cm (Schmidt & Cremmling, 1981).

Cleaning with steam jets

As with high pressure water, steam should be applied as a fan-shaped jet. The nozzle pressure should be about 3 MPa (400 PSIG), and the nozzle temperature about 130°C. The equipment should deliver 'wet' steam, by mixing water with the steam jet just before it leaves the

nozzle. Raising the nozzle temperature above 130°C will tend to 'dry' such steam, which will be less effective for cleaning than steam containing water droplets (Schmidt, 1983).

A steam jet can be applied effectively from distances up to 60 cm from a surface. Because of the higher temperatures obtained, the addition of a detergent to the added water does little to improve the cleaning efficacy of a 'wet' steam jet. When properly applied, a steam jet can clean with a single pass over a surface, when three or four passes with a high pressure water jet would be required to clean the same surface. However, the energy costs for steam cleaning are greater than those for water.

As steam jets are operated at a high nozzle temperature, some might assume that there is lethal heating of the bacteria on steam cleaned surfaces. Such is not the case. Even when the application of steam is prolonged, equipment surfaces are unlikely to rise to temperatures above 60°C, and bacteria embedded in an organic mensthum will die off only slowly at that temperature (Schmidt & Cremmling, 1981).

CLEANING BY HAND

Although mechanical cleaning will remove most soil from equipment, it will not remove the adhesive layer that forms when protein dries on to a surface, or crusted material on equipment surfaces that are warmed by friction (Schmidt, 1983). Such proteinaceous soil need not be of great hygienic concern if the surfaces are well dried after cleaning. They should, however, be periodically removed from food contact surfaces. Their removal will require scrubbing of the soiled areas with a scouring agent. Any non-disposable equipment used for scouring should be made of impermeable material, and be cleaned and dried after its use.

RINSING AFTER CLEANING

Mechanical cleaning will effectively remove soil, but in doing so it will generate copious amounts of steam and aerosols. During the immediate post-cleaning period, aerosol droplets that contain organic matter and bacteria will settle on equipment, and contaminated condensate may fall on equipment from overhead fixtures. The recontamination from those sources can be countered by rinsing equipment, with warm water applied at low pressure, approximately one hour after mechanical cleaning has been completed, and after any manual cleaning. Rinsing will also remove detergent residues that remain after cleaning with high pressure water.

DRYING

No cleaning regime will remove all organic material and bacteria. Thus, the remaining bacteria will continue growing on newly cleaned surfaces while there is sufficient moisture to support bacterial growth. Obviously, pooled water will contribute a greater bacterial load to a surface than a thin film of water. The bacterial burden will be reduced if pools of water are cleared from horizontal surfaces, and all bacterial growth will be prevented if the surfaces are dried. (Table 3).

Table 3. Flora recovered, before the start of processing, from dry and wet surfaces of the stainless steel slats of a loin trimming belt.

Condition of surface	No/cm ²	Microflora						
		Composition (%)						Non-spoilage types
		Spoilage types						
		Pse	Ac/M	F/A	Ent	Bro	Lac	
Dry	6.7x10 ²	36	50	---	---	2	---	12
Wet	6.9x10 ⁵	31	26	27	---	---	16	---

Pse=pseudomonads; Ac/M=acinetobacteria/moraxellae; F/A=flavobacteria/alteromonads; Ent=entrobacteria; Bro=*Brochothrix thermosphacta*; Lac=lactobacilli. Non-spoilage types = micrococci and bacilli.

It is therefore desirable to remove as much water as possible from equipment immediately after rinsing, and to arrange the air conditions within the fabrication facility to favour the evaporation of remaining moisture from the equipment.

Pooled water can be removed from horizontal surfaces using flexible scrapers. A more general removal of water can be achieved by means of suitable vacuum cleaning equipment.

TYPES OF SURFACE AND CLEANING EFFICACY

Surfaces that tend to retain soil in cracks, fissures or pores cannot be cleaned as effectively as smooth surfaces (Gilbert & Watson, 1971). Well cleaned and dried metal surfaces will carry bacteria at numbers between 10 and 10²/cm². Moreover, the flora on those readily cleaned and dried surfaces may well be composed predominantly of non-spoilage types. However, apparently well cleaned surfaces of rubbers and plastics, which are invariably scored and pitted during use, can be expected to carry a flora numbering about 10³/cm² that is composed predominantly of spoilage types. Any pervious, irregular surface will tend to retain moist soil, and carry a large flora of spoilage bacteria (Table 4).

Because the deterioration of surfaces enhances their capacities for retaining soil and bacteria, it is desirable to replace items of synthetic materials when their surfaces start to disintegrate, and to polish corroded or otherwise roughened metal surfaces.

DISINFECTION (SANITIZATION)

Three types of disinfectant (sanitizing agents) are commonly used in food plants. Those are chlorine release compounds, iodophors, and quaternary ammonium compounds, or quats (Table 5).

Table 4. Flora recovered from various surfaces after good cleaning and drying of pork fabrication equipment at a pig processing plant.

Type of surface	No/cm ²	Microflora						
		Composition %						Non-spoilage types
		Spoilage types						
		Pse	Ac/M	F/A	Ent	Bro	Lac	
Stainless steel, smooth	2.1x10 ¹	18	---	9	10	---	18	45
Stainless steel, pitted	3.6x10 ²	5	2	4	---	---	---	89
Rubber, scored	2.5x10 ³	2	43	20	7	---	12	16
Canvas* web	8.7x10 ⁵	52	4	14	---	27	3	---

Pse=pseudomonads; Ac/M=acinetobacteria/moraxellae; F/A=flavobacteria/alteromonads; Ent=entrobacteria; Bro=*Brochothrix thermosphacta*; Lac=lactobacilli. Non-spoilage types = micrococci and bacilli.

*Exposed by disintegration of the impervious surface of a belt of rubber coated canvas.

Table 5. Action characteristics of the principal types of disinfecting agents used in meat plants.

Action characteristic	Chlorine release compounds	Iodophors	Quaternary ammonium compounds
1. Action spectrum			
Gram + bacteria	+++	+++	+++
Gram - bacteria	+++	+++	+
Spores	+	+	--
Moulds	+++	+++	--
2. pH for action	acid	acid	alkaline
3. pH stability	alkaline	alkaline	acid
4. Inactivated by	organic matter alkaline detergents	organic matter temperature >45°C	anionic organic matter anionic surfactants

All three types of disinfectant are inactivated by organic material. Therefore, they are relatively ineffective on poorly cleaned surfaces. Moreover, they will be less effective on roughened or cracked surfaces, where the irregularities can harbour soil, than on smooth surfaces.

Microorganisms will be killed by disinfectants only when they are exposed to a sufficient concentration of the active agent for an adequate time. Sub-lethal concentrations will be, at best, bacteriostatic. Consequently, with continuous use of a single type of disinfectant, resistant strains of microorganisms are likely to become established in a plant.

The contact time required for killing tends to decrease with increasing temperature. However, iodophores tend to become inactive at temperatures above 45°C as the their active agent, iodine, evaporates. Iodine vapour so generated is hazardous to workers.

The halogen agents are most effective at acid pH values, but are more stable at alkaline pH. The chlorine releasing compounds have little disinfecting activity above pH 8.5, so cannot be used with alkaline detergents. In contrast, quats are relatively inactive at acid pH values, and are rapidly inactivated by anionic surfactants such as soaps.

The halogen agents have broad spectra of antimicrobial activity, but the quats are relatively ineffective against Gram-negative bacteria.

As a variety of factors affect the germicidal actions of the various disinfectants, a disinfectant must be chosen with due regard to the physical and chemical conditions under which it is expected to operate (Edelmeyer, 1980). No disinfectant will be of much value if surfaces are not well cleaned before its application, if it is greatly diluted by water pooled on equipment, or if insufficient time is allowed for the disinfectant to act. Clearly, unless the characteristics of a disinfectant are understood, it may be inappropriately applied to no hygienic benefit.

There is little point in expending excessive effort to produce surfaces with a bacterial load greatly below that of the material which is to be handled. At present, effective cleaning alone should produce meat contact surfaces that are less contaminated than the skins of the incoming carcasses. Therefore, the value of disinfection will be slight until such time as lightly contaminated pig carcasses can be provided to the fabrication facility.

If, however, it is desirable, at present or in altered, future circumstances, to make use of disinfectants, then the disinfectant solution should be applied as a mist or fine spray after the excess water has been mechanically removed from the equipment. Drying conditions should subsequently be maintained within the fabrication facility.

Because resident microbial populations will develop resistance to disinfectants that are applied continuously, the type of disinfectant used should be changed periodically.

RINSING BEFORE PROCESSING

It is a good hygienic practice to rinse equipment with warm water shortly before processing begins. That will mechanically remove many of the bacteria that may be present in persistent moisture films. A pre-processing rinse should always be used when a disinfectant has been applied, to remove disinfectant residues.

CLEANING OF PERSONAL EQUIPMENT

Although process workers must be encouraged to clean their personal equipment, such individual actions will not yield equipment that is consistently well cleaned. Therefore, all personal meat-contacting equipment should be deposited at designated areas within the fabrication facility, and be subjected to a routine cleaning process.

Impervious aprons can be cleaned with high pressure water or steam, provided that they are spread over, and anchored to, a rigid support, so that a smoothed surface is presented to the cleaning jets.

Knives, steels, scabbards, and steel mesh gloves and guards should be immersed in a warm detergent solution for approximately 30 minutes, then rinsed under a flow of warm water.

That treatment should be sufficient to clean all except the mesh items (Van Klink & Smulders, 1989). The construction of those items is such that dislodgment of all organic material is hardly possible, and they can readily harbour a large, persistent microflora (Table 6). Therefore, mesh items should be immersed in water of at least 80°C. Although most microorganisms are rapidly destroyed at that temperature, temperatures do not rise instantaneously, and the cooler equipment will tend to cool the wash water. Therefore, the mesh items should be immersed for some 5 to 10 minutes, to assure that all are exposed to an adequate heat treatment.

PREVENTION OF RECONTAMINATION DURING MAINTENANCE

Maintenance work in fabrication rooms is usually undertaken after the equipment has been cleaned. In accessing equipment, services or structures, soil may often be deposited on the cleaned equipment. The matter can be remedied by covering equipment threatened by soiling with plastic sheeting; by the usual tools and protective clothing of maintenance personal being of the hygienic standard appropriate for food processing work; and by hand cleaning of those areas that are unavoidably contaminated during maintenance work.

Table 6. The flora recovered, by rinse sampling, from mesh gloves before and during processing.

Time of sampling	No/glove	Microflora						
		Composition %						Non-spoilage types
		Spoilage types						
		Pse	Ac/M	F/A	Ent	Bro	Lac	
Before processing	1. 5.0x10 ⁸	2	1	23	---	21	8	45
	2. 1.2x10 ⁸	8	91	1	---	---	---	---
	3. 4.8x10 ⁷	14	50	6	8	9	13	---
During processing	1. 1.0x10 ⁹	25	44	10	4	7	---	10
	2. 4.4x10 ⁸	---	32	---	---	39	---	29
	3. 6.5x10 ⁷	20	22	38	2	---	4	14

Pse=pseudomonads; Ac/M=acinetobacteria/moraxellae; F/A=flavobacteria/alteromonads; Ent=entrobacteria; Bro=*Brochothrix thermospacta*; Lac=lactobacilli. Non-spoilage types = micrococci and bacilli.

ASSESSMENT OF CLEANING ADEQUACY

For any assessment to be of use, it must be performed consistently, and the findings communicated in an unambiguous and timely manner to those who can act on them.

VISUAL ASSESSMENT

The fundamental requirements for good cleaning are the removal of organic material from equipment surfaces, and the subsequent drying of clean surfaces to restrain the growth of residual contaminants (Dunsmore *et al.*, 1981). The only practicable method for rapidly and routinely assessing the adequacy of cleaning is visual inspection.

The assessments made from a visual inspection will be fundamentally subjective. However, individual judgments can be constrained to relative consistency by the use of a formal scoring system that identifies types and degrees of defect (Fig. 2). A defect scoring sheet can be used in conjunction with a sheet that identifies any items of equipment that were inadequately cleaned (Fig. 3).

Visual inspection should involve not only the exposed surfaces of equipment, but also those areas that are guarded or obscured. It may therefore be impracticable to inspect all equipment in adequate detail on every day. In that case, the fabrication facility should be divided into convenient sections, with daily inspection of a single section selected on a random basis.

Fig. 2. Sheet for the identification of cleaning defects.

CLEANING DEFECT

x

 Indicates the defect(s) observed

EQUIPMENT:

DATE:

DEFECT	DEGREE	
A. Water	1. Film	
	2. Drops	
	3. Pools	
B. Fat	1. Film	
	2. Globules	
	3. Large deposits	
C. Soil	1. Film	
	2. Small particles	
	3. Large particles or deposits	

COMMENTS:

INSPECTOR:

Fig. 3. Sheet for the documentation of inadequately cleaned equipment.

CLEANING INSPECTION

CARCASS FABRICATION EQUIPMENT 2

Loin and Belly Fabrication Lines

☒ Indicates inadequate cleaning

☐ midpiece fab belt
☐ loin/belly saw

☐ loin skinner
☐ loin trim belt
☐ loin trim belt drive

☐ belly transfer belt
☐ belly fab belt
☐ belly compactor
☐ belly skinner
☐ belly trim belt

DATE:

INSPECTOR:

The principal purpose of routine inspection should be clearly understood. It is not to identify miscleaned equipment before each processing shift so that some remedial action can be instigated. Instead, it is to progressively eliminate poor practices in routine cleaning, so that cleaning procedures of assured and consistent efficacy are developed. As good practice becomes established the intensity of inspection can be reduced, to that which suffices to ensure that mispractices do not develop. It is, however, at all times essential that the findings from an inspection are communicated immediately to the person responsible for overseeing the cleaning activity, and that agreement is reached on the appropriate remedial action for any cleaning inadequacy.

Cleaning performance should be appropriately charted, so that persistent areas of inadequacy, and trends in cleaning performance, can be readily appreciated by all parties involved.

MICROBIOLOGICAL MONITORING

The purposes of microbiological monitoring are to calibrate the visual judgments in objective terms that are relevant to hygiene, and to detect inappropriate practice that may not be apparent to uninformed inspection.

The only surfaces from which samples for microbiological analysis can always be conveniently obtained are the horizontal surfaces on which meat is placed. Surface areas of 100 cm², each delimited by sterilized template, should each be sampled by swabbing with a sterile gauze swab (5x5 cm) moistened with 5 ml of sterile 0.1% peptone water. During swabbing the swab can be gripped through a plastic bag inverted over the hand. Five such swabs from random points on the appropriate surface of a piece of equipment are collected into a stomacher bag containing 75 ml of chilled peptone water. The equipment being sampled and associated equipment (eg. saws) should then be switched on for 5 to 10 minutes without the passage of product, and the sampling repeated.

After stomaching within 1 h of their collection, a dilution series of each homogenate should be prepared, and 0.1 ml portions of suitable dilutions spread on duplicate plates of Plate Count or Standard Methods Agar. Colonies should be counted after plates have been incubated for 48 h at 25°C.

Over a period, the numbers of bacteria that are recovered from various well-cleaned surfaces will become apparent. If the number obtained after operating equipment are substantially higher ($>\log 0.5$) than the first count, an unobserved source of contamination is indicated (Table 7). The source of that contamination should be identified by close inspection of the cleaned equipment, and an appropriate procedure adopted for its elimination.

THE TIME OF INSPECTION AND SAMPLING

Equipment should be inspected and sampled at a time conveniently close to the start of production, but before pre-production rinsing of equipment when such is the usual practice.

CLEANING IN RELATION TO PRODUCT QUALITY

Cleaning of equipment should be viewed as an activity that is essential for the maintenance of product quality. Good cleaning is needed to assure the safety of product with respect to public health, and the stability of product during storage. Poor cleaning practice can lead to product being excessively contaminated with a particular pathogen and/or product of uncertain and variable storage life. Both of these defective conditions of product can be the cause of large financial losses.

Assured avoidance of losses arising from product being of poor hygienic quality is possible only through an effective quality assurance program. Although effort and expenditure may be required to establish effective cleaning, once firmly established the ongoing costs will likely be no greater than those associated with ineffective procedures. The benefits of good cleaning can therefore be expected to substantially outweigh the cost. Hence, effective cleaning should be an activity of acknowledged priority at any well managed pig processing plant.

SUMMARY OF EQUIPMENT CLEANING/INSPECTION PROCEDURES

1. Assure proper locations of movable and personal equipment.
2. Place items of personal equipment to soak in warm (>50 °C) detergent solution.
3. Open or remove guards from equipment to expose the guarded surfaces.
4. Brush or scrap accumulations of detritus from the equipment.
5. Clean equipment and impervious aprons with jets of high pressure hot water or 'wet' steam.
6. Manually scour any adhesive or crusted material from food contact surfaces.
7. Agitate personal equipment items in the soaking solution. Remove them from soaking, rinse under running water, and immerse the equipment in water at a temperature >80 °C for at least 5 min. Place equipment on racks to dry.
8. Rinse the cleaned large items of equipment with warm water.
9. Dry equipment using flexible scrappers, then vacuum cleaning equipment.
10. Adjust conditions in the fabrication facility to favor drying-out of the equipment.
11. Apply a solution of a suitable disinfecting agent as a spray or mist.
12. Inspect equipment for cleaning defects before processing commences.
13. Obtain microbiological samples from the food contacting surfaces of selected items of equipment. Collect samples before and after operation of the equipment for 10 min.
14. Rinse the equipment with warm water before processing begins.

Table 7. The microflora recovered from cleaned equipment at two plants before start-up and after operating equipment for 10 min. without passage of product.

Equipment item	Sampling time	No/cm ²	Microflora						
			Composition %						
			Spoilage types						Non-spoilage types
			Pse	Ac/M	F/A	Ent	Bro	Lac	
Loin skinner belt 1.	Before start-up	1.1x10 ⁴	---	37	2	---	---	---	61
	After operating	2.0x10 ⁵	33	47	5	3	---	7	5
Loin trim belt 1	Before start-up	6.7x10 ²	4	3	1	---	---	---	92
	After operating	3.2x10 ⁴	26	22	---	2	---	8	42
Loin skinner belt 2	Before start-up	6.6x10 ³	46	45	2	---	---	3	4
	After operating	4.2x10 ³	33	10	3	---	7	---	47
Loin trim belt 2	Before start-up	3.7x10 ²	36	50	---	---	2	---	12
	After operating	2.4x10 ⁴	67	15	8	---	9	---	1

Pse=pseudomonads; Ac/M=acinetobacteria/moraxellae; F/A=flavobacteria/alteromonads; Ent=enterobacteria; Bro=*Brochothrix thermosphacta*; Lac=lactobacilli. Non-spoilage types = micrococci and bacilli.

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